OIPE JC177
MAR 0 5 2004
PATENT & TRADEMARK OFFICE

Atty. Dkt. No. 016907-1580

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant:	Naofumi YAMAMOTO et al.
Title:	IMAGE PROCESSING APPARATUS AND IMAGE PROCESSING METHOD
Appl. No.:	10/700,527
Filing Date:	11/05/2003
Examiner:	Unassigned
Art Unit:	2621

SUBMISSION OF VERIFIED TRANSLATION
UNDER 37 C.F.R 1.78(a)(5)(iv)

Commissioner for Patents
PO Box 1450
Alexandria, Virginia 22313-1450

Sir:

Submitted herewith is an English translation of provisional application Serial No. 60/459,999, filed April 4, 2003. A translator's declaration is attached verifying that this is an accurate translation of the previously filed provisional application.

Respectfully submitted,

Date March 5, 2004

RN38072

By ______________________

Pavan K. Agarwal
Attorney for Applicant
Registration No. 40,888

FOLEY & LARDNER LLP
Customer Number: 22428
Telephone: (202) 945-6162
Facsimile: (202) 672-5399

TRANSLATION

I, Kenji Kobayashi, residing at 2-46-10 Goko-Nishi, Matsudo-shi, Chiba-ken, Japan, state:

that I know well both the Japanese and English languages;

that I translated, from Japanese into English, the specification, claims, abstract and drawings as filed in U.S. Provisional Patent Application No. 60/459,999 filed April 4, 2003; and

that the attached English translation is a true and accurate translation to the best of my knowledge and belief.

Dated: February 10, 2004

Kenji Kobayashi

Kenji Kobayashi

PROVISIONAL APPLICATION

TITLE OF THE INVENTION

IMAGE PROCESSING APPARATUS

BACKGROUND OF THE INVENTION

The present invention relates to an image processing apparatus for subjecting an input color image to image processing, for example, in a digital color copying machine that reads a color image on an original and forms a copy image of the color image.

A conventional image region discrimination method for a color image has problems listed below. It is thus difficult to satisfy all requirements for a discrimination precision, circuitry scale and processing speed.

1. In a method using only micro-scoped discrimination, erroneous discrimination frequently occurs. In particular, erroneous discrimination tends to occur on an edge part of a tone image and on an inside part of a thick character. Consequently, high discrimination precision cannot be obtained.

2. In a method using both micro-scoped discrimination and macro-scoped correction, the possibility of erroneous discrimination becomes lower than in the above method. However, there is no remarkable improvement in the erroneous discrimination on an edge part of a tone image and on an inside part of a thick character. Besides, if a macro-scoped correction

process is executed by hardware, the circuitry scale becomes greater in accordance with the size of a reference region. Thus, there is a limit to improvement in precision.

3. In a method using both macro-discrimination and micro-scoped discrimination, a computational processing time increases. To shorten the processing time will incur an increase in cost of circuitry or a decrease in discrimination precision.

BRIEF SUMMARY OF THE INVENTION

The object of the present invention is to provide an image processing apparatus capable of performing an image region discrimination process that can satisfy all requirements for a discrimination precision, circuitry scale and processing speed.

Additional objects and advantages of the invention will be set forth in the description which follows, and in part will be obvious from the description, or may be learned by practice of the invention. The objects and advantages of the invention may be realized and obtained by means of the instrumentalities and combinations particularly pointed out hereinafter.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING

The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate presently preferred embodiments of the invention, and together with the general description

given above and the detailed description of the preferred embodiments given below, serve to explain the principles of the invention.

FIG. 1 is a block diagram showing the structure of an image processing section according to a first embodiment of the invention;

FIG. 2 shows the structure of a color conversion section according to the first embodiment;

FIG. 3 shows frequency characteristics of filters in the first embodiment;

FIG. 4 shows screen patterns of a tone processing section in the first embodiment;

FIG. 5 shows the structure of an image region discrimination section in the first embodiment;

FIG. 6 shows an example of an original image;

FIG. 7 shows examples of characteristic amount calculation results for an original image;

FIG. 8 is a flow chart of a processor process in the image region discrimination section according to the first embodiment;

FIG. 9 is a view for explaining a smearing process;

FIG. 10 is a view for explaining the smearing process;

FIG. 11 shows an example of the result of a macro-scoped correction process;

FIG. 12 illustrates an operational sequence in the

first embodiment;

FIG. 13 shows the structure of an image processing section according to a second embodiment of the invention;

FIG. 14 shows the structure of an image region discrimination section in the second embodiment; and

FIG. 15 illustrates an operational sequence in the second embodiment.

DETAILED DESCRIPTION OF THE INVENTION

Embodiments of the present invention will now be described with reference to the accompanying drawings.

To begin with, digital recording is described.

In these years, there have been an increasing number of apparatuses, such as facsimiles, document files and digital copying machines, wherein document images are treated as digital signals. To treat images as digital signals is very advantageous since it permits various editing/correcting processing and easy storage and transmission. Conventionally, such digital image processing apparatuses mainly handle monochromatic binary images, for example, characters and line images. In recent years, however, such apparatuses have been applied to tone images and color images.

Next, the need for image region discrimination is explained.

In handling an image including a character portion

and a tone image portion, a problem arises with the recording on a hard copy. Electrophotography is widely used for recording digital images. Normally, the ability of density expression in this method is low. That is, the density per picture dot is expressed by only two levels or several levels. Thus, in order to express a tone image, an area modulation is performed using a pulse width modulation method or a dither method. In general terms, if the unit for area modulation is enlarged, stable tone reproducibility is obtained but the resolution decreases.

On the other hand, if the area unit is reduced in size, the tonal stability decreases but the resolution increases. It is difficult to perform image recording with both high resolution and high tonal stability, using only one kind of area modulation unit.

In order to perform image recording with both high resolution and a good tone rendition, an image region discrimination process is used.

Specifically, an image to be recorded is discriminated into a part, e.g. a photo part, for which a tone rendition is important, and a part, e.g. a text part, for which resolution is important. Based on the discrimination result, a recording process is switched.

A conventional image region discrimination method will be described below.

Image region discrimination methods, in general terms, fall into three categories: micro-scoped discrimination which uses a difference in local characteristic such as microscopic image density or density variation; macro-scoped correction which makes fine corrections of a discrimination result by referring to a micro-scoped discrimination result in a macro-scoped of a certain size; and macro-discrimination which discriminates a region on the basis of a result of general analysis of document structure.

Next, the aforementioned micro-scoped discrimination is explained.

The following methods are known as examples of micro-scoped discrimination.

(1) An image is divided into small blocks. A difference between a maximum density and a minimum density in each block is found. If the difference is greater than a threshold, the block is discriminated as a character image region. If the difference is less than the threshold, the block is discriminated as a tone image region. (Jpn. Pat. Appln. KOKAI Publication No. 58-3374)

(2) An image is subjected to a Laplacian filter, and then digitized. For example, based on a pattern shape of 4 × 4 pixels of the digitized image data, discrimination is performed. (Jpn. Pat. Appln. KOKAI

Publication No. 60-204177)

In the method (1), if an image comprises only a continuous tone image part, such as a photo, and a character part, discrimination can be performed with high precision. However, the precision in discrimination is very low in a region with a large local density variation such as a halftone-screen image region.

Besides, if there is a sharp edge on a tone image, it may possibly be erroneously discriminated as a character part. In the method (2), a halftone-screen image can be discriminated as a tone image. However, like the method (1), an edge part on a tone image tends to be erroneously discriminated as a character image part.

There is known a technique wherein different micro-scoped discrimination methods are combined, and the respective discrimination results are synthesized to produce a final discrimination result. In this technique, the presence/absence of an edge part is basically discriminated. It is thus difficult to increase the precision in discrimination between an edge part of a tone image and a character part, or in discrimination of an inside of a thick character.

The aforementioned macro-scoped correction is explained.

There is known macro-scoped discrimination wherein

micro-scoped discrimination is first performed and then correction is made by referring to a discrimination result of a region near a pixel of interest, making use of the feature that an image region, such as a halftone-screen region or a photo region, is constant in a relatively broad range. With this method, the precision in discrimination can be improved. However, if a macro-scoped is set as a reference region, the circuitry scale increases, leading to a rise in cost. In addition, since an edge part is basically detected, like the above method, it is difficult to enhance the precision in discrimination between an edge part of a tone image and an inside part of a thick character.

Next, the aforementioned macro-discrimination is explained.

In the macro-discrimination, the structure of a document is analyzed, and a text region and a photo region are discriminated in units of a region. An example is disclosed in the following document: "Extraction algorithm of text region for mixed-mode communication", IEICE (the Institute of Electronics, Information and Communication Engineers), Trans., J67-D, vol. 11, pp. 1277-1284 (1984).

This document discloses a technique of analyzing a document structure from information on an entire document image, making use of knowledge of a general layout structure of a document text, a heading, a

figure and a photo.

The macro-discrimination uses a layout structure of a document image and thus a text region and a tone image region can be discriminated with high precision. However, since the processing from recognition to layout analysis is performed mainly by software, an enormous length of processing time is disadvantageously required. Although the use of a high-speed processor can enhance the processing speed, there is a trade-off between the high speed and the cost.

In general, in order to decrease the amount of calculations and simplify software, the processing is performed by limiting a unit region for discrimination to a rectangle, or by converting an input image to one with low density. In this case, however, the discrimination unit (resolution) becomes coarse. This technique is not satisfactory when a region to be discriminated is finely complicated as in a case of a character on a halftone-screen background.

The use of the combination of micro-scoped discrimination and macro-discrimination will be explained below.

In order to make use of the advantageous features of both the micro-scoped discrimination and macro-discrimination, the use of the combination thereof is proposed (Jpn. Pat. Appln. KOKAI Publication No. 11-69150).

In this technique, a macro-discrimination process is performed on an image that is read with a low (rough) resolution, and a micro-scoped discrimination process is performed on an image that is read with a high (fine) resolution. The results of both discrimination processes are synthesized to obtain a final discrimination result. Thereby, the image region discrimination can be effected with a high discrimination precision and a high pixel resolution.

However, the macro-discrimination is performed by software in this method. Hence, like the above-described method, the processing time is disadvantageously increased.

In the present invention, in order to solve the above problems, micro-scoped discrimination is first conducted by making use of local characteristic differences. Then, the result of the micro-scoped discrimination is subjected to a macro-scoped correction process by the processor and software. Further, based on the obtained signal, the general structure of the original image is analyzed and macro-discrimination is performed. By synthesizing these results, a final discrimination result is calculated.

By combining the micro-scoped discrimination and macro-discrimination in the above manner, a high-precision, high-resolution discrimination process can be performed.

In addition, characteristic amount computation for a small reference region is performed by hardware, and macro-scoped correction processing and macro-discrimination for a large reference region are performed by software. Thereby, a discrimination process, wherein a hardware scale and a processing computation speed are well balanced, can be realized.

The structure of a first embodiment of the invention will now be described.

The embodiment is described referring to the accompanying drawings.

FIG. 1 is a block diagram showing the structure of a digital color copying machine having an image region discrimination section 1. The digital color copying machine comprises an image input section 101, an image processing section 1 functioning as an image processing apparatus, and an image recording section 109. The image processing section 1 includes an encoding section 102, a page memory 103, a decoding section 104, the aforementioned image region discrimination section 105, a color conversion section 106, a filter section 107 and a tone processing section 108.

The present invention is applied to the image region discrimination section 105. A description of editing processes such as an enlargement/reduction process, a trimming process and a masking process is omitted here, since these processes are not directly

related to the present invention. Processing sections for these processes are disposed, for example, immediately after the image input section 101.

The whole structure and the content of the processing are described in brief.

To begin with, the structure of the image input section is described.

The image input section 101 reads or scans an original image (an image on an original) and outputs a color image signal 151.

The color image signal represents RGB reflectances of each pixel on the original, and is produced as three time-series signals acquired by two-dimensionally scanning the information of each pixel. In this case, the number of pixels scanned per unit length is called "pixel density". In the present embodiment, the scan density is 600 dpi, that is, a density of 600 pixels per 25.4 mm.

Next, the structures of the encoding/decoding sections and page memory are described.

The color image signal 151 output from the image input section 101 is compression-encoded by the encoding section 102, and the encoded signal is stored in the page memory 103. The color image signal stored in the page memory 103 is decoded by the decoding section 104 and is output as a color image signal.

The structure of the image region discrimination

section is described.

The image region discrimination section 105 receives the color image signal 152 and discriminates the attributes of pixels based on the color image signal 152. The image region discrimination section 105 outputs the discrimination result as a discrimination signal 153. In this embodiment, the following four kinds of attributes of pixels are discriminated:

1. black character,
2. chromatic character,
3. halftone-screen tone image, and
4. continuous tone image.

The discrimination signal 153 takes a value of any one of the above four kinds. The image region discrimination section 105 is the main point of the present invention. The structure and function of the image region discrimination section 105 will be described later in detail.

The structure of the color conversion section is described.

The color conversion section 106 converts the RGB color image signals 151 representing RGB reflectances on one original to CMYK density signals 156 representing densities of color materials to be recorded. FIG. 2 shows the structure of the color conversion section.

The conversion from RGB color image signals to

CMYK density signals is effected by the combination of the reference to rough lookup tables (LUTs) and an interpolation process. The LUT has input addresses of 9 × 9 × 9 or 17 × 17 × 17, and outputs CMYK values of (8 bits × 4 colors).

The input of each table corresponds to the RGB color image signals, and the output thereof corresponds to CMYK density signals.

The upper 3 bits (or upper 4 bits) of each RGB color image signal are used for selection, and the lower 5 bits (or 4 bits) are used for the interpolation process of, e.g. primary interpolation.

Two kinds of LUTs are prepared for a photo region and a text region.

The LUT for a photo region increases a black ratio in a region near black, placing a stress on tone reproducibility. On the other than, the LUT for a text region extremely increases a black ratio in a chromatic region near black, so that only black may substantially be printed. Thereby, no color blur occurs even if there is a color registration error or a print position error among YMCK colors, and a sharp black character can be reproduced.

An example of the relationship between the discrimination signal and LUTs is shown below.

1. black text region ... table for text region
2. chromatic text region ... table for text region

3. halftone-screen tone image ... table for photo region

4. continuous tone image ... table for photo region.

Next, the structure of the filter section 107 is described.

The filter section 107 selectively switches filters for respective components of the CMYK density signals in accordance with the discrimination signal output from the image region discrimination section.

In a text region, in order to sharply record a character, a sharpening process (edge emphasis) is performed on a chromatic component of the character.

In a halftone-screen photo region, in order to prevent occurrence of moiré or the like, a smoothing process is performed to remove a halftone-screen component.

In a continuous photo region, in order to enhance sharpness, a band emphasis filter is used. An example of the relationship between the discrimination signal and filter characteristics is shown below. FIG. 3 indicates frequency characteristics of each filter.

1. Black text region ... The high-frequency emphasis filter is used for a K signal, and the smoothing filters are used for CMY signals.

2. Chromatic text region ... The high-frequency emphasis filter is used for CMY signals, and the

smoothing filter is used for a K signal.

3. halftone-screen tone image ... The smoothing filter is used for CMYK signals.

4. Continuous tone image ... The band emphasis filter is used for CMYK signals.

Next, the structure of the tone processing section 108 is described.

In an electrophotographic recording process, it is difficult to stably express multi-gray-level densities in units of a pixel. Normally, using an area modulation method, an intermediate density is expressed by a pattern of plural pixels (hereafter referred to as "screen pattern"). In this method, if the period of the screen pattern is increased, the number of gray levels and the tonal stability are enhanced, but the expressional resolution is degraded. On the other hand, if the period of the screen pattern is decreased, the expressional resolution is enhanced but the number of gray levels and the tonal stability are degraded. Thus, a plurality of screen patterns are selectively used. For example, a screen pattern with a large period is used for an image such as a photo that requires a good tone rendition or stability, and a screen pattern with a small period is used for an image such as a character or a line that requires a high resolution rather than a good tone rendition.

In this embodiment, the tone processing section

108 performs the area modulation process and switches a plurality of modulation patterns in accordance with the discrimination signal. Thereby, as regards a photo region, an image with a smooth gradation and good tone rendition can be reproduced. In addition, as regards a text region, a sharp image can be recorded. FIG. 4 shows examples of screen patterns for a character and a photo.

The relationship between the discrimination signal and screen patterns is shown below.

1. Black text region ... CMY signals: photo region pattern, K signal: text region pattern,

2. Chromatic text region ... CMY signals: text region pattern, K signal: text region pattern,

3. halftone-screen tone image ... CMYK signals: photo region pattern,

4. Continuous tone image ... CMYK signals: photo region pattern.

The structure of the image recording section 109 will now be described.

In this embodiment, electrophotography is used in the image recording section 109. The principle of electrophotography is described in brief. A laser beam is intensity-modulated according to an image density signal. The modulated beam is applied to a photosensitive drum. A charge corresponding to the amount of the radiated beam occurs on the photosensitive

surface of the photosensitive drum.

Thus, a two-dimensional charge distribution corresponding to the image signal is formed on the photosensitive drum by causing the laser beam to scan the photosensitive drum in the axial direction of the photosensitive drum in accordance with the scan position of the image signal and by rotating the photosensitive drum in accordance with the scanning. Subsequently, a developing device applies a charged toner to the photosensitive drum. At this time, the toner, whose amount corresponds to potential, is attached to the photosensitive drum and an image is formed on the photosensitive drum. Then, the toner image on the photosensitive drum is transferred to recording paper via a transfer belt. Finally, the transferred toner image is fused and fixed on the recording paper by a fixing device. This operation is successively performed for four color toners of YMCK. Thus, a full-color image is recorded on the paper.

With the above-described structures, a proper process can be executed according to regions of an image, and it becomes possible to record a high-quality document image including a photo region and a text region, or a chromatic character and a black character.

However, in order to perform this process, it is necessary that the image region discrimination section 105 execute a correct discrimination process and

produce the discrimination signal.

Next, the image region discrimination section 105 is described in detail.

The image region discrimination section 105 discriminates the kind of an image. FIG. 5 shows the structure of the image region discrimination section 105.

The characteristic amount calculation sections 501 to 504 receive RGB color image signals and calculate and produce binary or multi-value characteristic amounts corresponding to local densities, density variations and variation patterns of the received RGB color image signals.

The characteristic amount calculation section 501 calculates the degree of a linear edge in units of a pixel and outputs an edge characteristic amount corresponding to the degree of linear-edge-like quality. A pixel on an edge part has a large edge characteristic amount, and a part other than the edge has a smaller edge characteristic amount. Specifically, based on the RGB color image signals 152, a luminance signal Y is calculated according to the following linear addition arithmetic operation:

$$Y = Ar \times R + Ag \times G + Ab \times B$$

$$(Ar = 1/3,\ Ag = 1/3,\ Ab = 1/3).$$

The luminance signal Y is subjected to, e.g. 8-directional edge detection filters. Referring to the

filtered output values, it is determined whether an edge amount in a specified direction is large, and the determination result is output.

Alternatively, without using the luminance signal, the same calculations may be performed on the RGB signals, and maximum values of calculation results of the RGB components may be output.

The characteristic amount calculation section 502 produces a halftone-screen characteristic amount representing whether a region under consideration is a halftone-screen region or not. A large value is output for a region which is possibly a halftone-screen region, and a small value is output for other regions. This signal, like the edge characteristic amount, is determined by computing a luminance signal from the RGB color image signals, subjecting the luminance signal to an 8-directional edge detection filtering process, and determining whether the directions of edges are various or not.

The characteristic amount calculation section 503 calculates an achromatic characteristic amount S on the basis of the balance among RGB values of color image signals. If a pixel has an achromatic color such as white, black or gray, the achromatic characteristic amount S takes a value "0" or a small value. If a pixel has a color with a high chroma saturation, such as red, yellow, green or blue, the achromatic

characteristic amount S takes a large value.

The achromatic characteristic amount S is calculated, for example, by the following equation:

$$S = \max(R, G, B) - \min(R, G, B).$$

The characteristic amount calculation section 504 calculates a luminance signal Y from RGB color image signals, expresses the luminance signal Y by three values, and produces a halftone characteristic amount Sc and a white background characteristic amount Sw.

To be more specific, the luminance signal Y is compared with two thresholds, Thy1 and Thy2 and a luminance level signal Y' is computed according to the following conditional expressions:

if $(Y < Thy1)$, then $Sc = 0$, $Sw = 0$

if $(Y \geqq Thy1)$ and $(Y < Thy2)$ then $Sc = 1$, $Sw = 0$

if $(Y \geqq Thy2)$ then $Sc = 0$, $Sw = 1$.

This signal represents a background region (Sw = 1), which is a region with no print image, or a halftone region (Sc = 1) such as a photo region, or a region (Sw = Sc = 0) such as a black text region, which is neither the background region nor the halftone region.

Based on the above principle, the thresholds Thy1 and Thy2 are preset.

In this embodiment, the characteristic amount calculation sections 501 to 504 use a common signal such as the luminance signal Y. Thus, these

calculation processes, for example, may be commonly performed. This can reduce the circuitry scale. The respective characteristic amounts output from the characteristic amount calculation sections 501 to 504 are input to the synthesizing processing section 505 and comprehensively determined by the synthesizing processing section 505.

Further, the characteristic amounts output from the characteristic amount calculation sections 501 to 504 are subjected to conversion of a low density and a bit amount and are divisionally stored in the memory 510 in association with the individual characteristic amounts.

The conversion processing sections 506 to 509 in this embodiment calculate mean values of pixel values within a region of 9 pixels (3 pixels (vertical) × 3 pixels (horizontal)) with respect to multi-value signals of the edge characteristic amount, halftone-screen characteristic amount and saturation characteristic amount. Then, each of the conversion processing sections 506 to 509 digitizes and converts each characteristic amount into a signal with a value of "0" or "1". As regards the background characteristic amount and halftone characteristic amount, a majority-decision process is performed in a region of (3 pixels (vertical) × 3 pixels (horizontal)) and a result of the majority-decision process is

output.

By the conversion process, the signal amount stored in the memory can be decreased. In addition, the calculation amount for the macro-scoped correction process and macro-discrimination, as described below, can be decreased.

An example of computation of characteristic amounts is described below.

A computation result of characteristic amounts corresponding to an original image is exemplified. FIG. 6 shows an example of an original image. For the purpose of simple description of discrimination processing, the original image has a schematic structure comprising a black text region 601, a chromatic text region 602, a character-on-halftone-background region 603, a halftone photo region 604 and a continuous photo region 605. The character-on-halftone-background region is a region where a black character is printed on a uniform halftone-screen hatching background.

Portions (a) to (e) in FIG. 7 show calculation results of the five kinds of characteristic amounts of the original image.

Next, the process executed by the processor 511 is described.

The processor 511 performs a macro-scoped correction process and a macro-discrimination process

for the characteristic amounts stored in the memory 510. This process is executed according to a program stored in the program memory (ROM) 512. In this embodiment, a SIMD (Single Instruction Multiple Data)-type processor and a sequential-type processor are both used. The SIMD-type processor is capable of simultaneous parallel execution of the same process. In steps 1 to 4, the same process is executed for each pixel, and so the use of this processor realizes high-speed computation.

Alternatively, a general-purpose CPU for CISC or RISC may be used.

The specific procedure of the process executed by the processor will be described in detail with reference to FIG. 8.

In step 1, the white background characteristic amount is subjected to a smearing process, and a white background region is determined. In the smearing process, the pixel values of pixels interposed between two pixels, which meet the condition that both pixels have a value "1" and have an inter-pixel distance of a predetermined value ThSm or less, are corrected to "1".

FIG. 9 shows an example of this process.

In this step 1, a white background region on the original image is detected. The white background region includes a white part of the original paper and a character/figure area on the white part. That is,

the white background region is a region other than a photo region and a graph/table area on a chromatic background. However, in the original characteristic amount, a text part on a white background is not determined to be a white background region. Thus, the smearing process is performed, and the pixel values corresponding to a fine text part on a white background are corrected to "1". Therefore, the precision in determining the white background region is enhanced.

In subsequent step 2, the edge characteristic amount is subjected to a smearing process, and the result of the process is produced as a text region signal. In principle, only an edge part has a value "1" as an edge characteristic amount, and an inside part of a thick character is not regarded as an edge part. The result of the smearing process is determined to be a text region, and so an inside part of a thick character is determined to be a text region. In addition, a predetermined value of a distance is set at a value approximately equal to an inter-character distance, whereby character strings arranged in rows can be connected and extraction of character strings in macro-discrimination (to be described later) can be facilitated.

FIG. 10 shows an example of this process.

In this embodiment, the smearing process is performed only with respect to pixels, which have equal

coordinates in the main scan direction or sub-scan direction, in consideration of easier design of software and a computation speed of software. However, if discrimination with higher precision is required, smearing may be performed in an oblique direction of 45℃ or a given angle.

In step 3, the halftone-screen characteristic amount is subjected to a majority-decision process. In the majority-decision process, the number of pixels with pixel value "1", which are included in pixels adjacent to a pixel of interest, is counted. If the count value is greater than a predetermined value, an output value "1" is produced. If it is less than the predetermined value, an output value "0" is produced.

In general, a halftone-screen characteristic amount is often discriminated erroneously, and cyclically varying signals are obtained on half-screen regions. In a non-halftone-screen region, too, end portions of lines, for instance, are erroneously discriminated sporadically. By executing the majority-decision process, such erroneous discrimination can be prevented and a high-precision halftone-screen region signal can be obtained.

In step 4, the achromatic characteristic amount is subjected to a smearing process.

In the present embodiment, a smearing process is performed only in the sub-scan direction. The purpose

of this process is to correct color-difference noise due to color misregistration caused by, e.g. vibration at the time of image reading. In a color scanner having a 3-line sensor that is widely used for color image input, vibration of the carriage causes a relative displacement of read positions of RGB signals. This may result in color-difference noise. This phenomenon is conspicuous on a black character or an edge portion of a black line. An edge part of a black character, which should normally be achromatic, is determined to be chromatic due to imbalance of RGB signals. This problem occurs only at edge parts in the sub-scan direction. Thus, the problem can be solved by performing the smearing process in the sub-scan direction, as in this embodiment.

Portions (a) to (e) of FIG. 11 show examples of results of macro-scoped correction processes in steps 1 to 4, which are executed for the characteristic amounts in FIG. 7.

The macro-scoped correction process can correct the omission of a halftone-screen characteristic amount in a halftone-screen region, the determination of an inside part of a character edge, and the color misregistration of a black character due to scanner jitter.

In step 5, macro-scale discrimination is performed on the basis of output signals in steps 1 to 4. In

steps 1 to 4, high-connectivity region signals are obtained since the occurrence of erroneous discrimination is reduced by the smearing process and majority-decision process. In step 5, connectivity is determined with respect to the white background region, halftone region, text region and halftone-screen region, and a connected rectangular region is extracted. Then, the attribute, size, positional relationship and inclusive relationship of the extracted connected region are examined to determine the kind of the region.

Finally, the region under consideration is discriminated as one of the following four kinds:

1. background graphic
2. halftone-screen background graphic
3. halftone-screen photo
4. continuous photo.

For example, if a plurality of text regions lie on a halftone-screen region, the region under consideration is determined to be a halftone-screen background graphic. A region, which is a halftone region of a predetermined size or more and does not overlap a halftone-screen region, is determined to be a continuous photo region.

Detailed algorithms for macro-discrimination are disclosed in Jpn. Pat. Appln. KOKAI Publication No. 11-69150. The discrimination result is stored in

the memory 511 as macro-discrimination information of 2 bits per pixel. The macro-discrimination information is stored as a position information table, but it may be stored as bitmap information. When the macro-discrimination process is completed, the macro-discrimination information stored in the memory 511 is converted to a time-series bitmap image signal in sync with a predetermined signal, and the time-series bitmap image signal is delivered to the synthesizing processing section.

The timing and sequence of the signal process at this time will be described later.

Finally, the synthesizing processing section 505 executes a comprehensive discrimination process using the characteristic amounts output from the characteristic amount calculation sections 501 to 504 and the macro-discrimination information output from the memory 510.

Next, the process sequence is described.

The sequence of the signal processing in an ordinary copying operation is described in detail. FIG. 12 illustrates the process sequence.

A color image signal read by the image input section 101 is encoded by the encoding section 102 and stored in the page memory 103. At the same time, the color image signal is delivered to the image region discrimination section 105. In the image region

discrimination section 105, the characteristic amount calculation sections 501 to 504 perform first characteristic amount calculations, and the calculation result is stored in the memory 510. In this way, the first characteristic amount calculations and encoding are executed at the same time. Subsequently, the processor 511 executes the macro-scoped correction process and macro-discrimination process. After the macro-discrimination process is completed, the macro-discrimination result is read out of the memory 510 and, at the same time, the encoded image signals are read out of the page memory 103 and are decoded into RGB color image signals 152 by the decoding section 104. The decoded color image signals 152 are input to the image region discrimination section 105 and color conversion section 106. In the image region discrimination section 105, second characteristic amount calculations are performed, and the results of the second characteristic amount calculations are output to the synthesizing processing section 505.

Thereby, the results of the second characteristic amount calculations and the macro-discrimination information are input to the synthesizing processing section 505 at the same time, and the synthesizing process is carried out. In addition, at the same time, the decoded image signal is subjected to color conversion processing, filter processing and tone

processing. These processings are performed suitably for regions of the image, with the discrimination signal being received from the synthesizing processing section 505.

The points of the present invention according to the first embodiment are as follows.

The characteristic amount calculation results obtained by hardware are subjected to the macro-scoped correction and macro-discrimination by the processor.

The resolutions and signal bit amount of the characteristic amounts are decreased, and the resultant signals are stored in the memory.

Both the macro-discrimination information and characteristic amounts are synthesized to produce a final discrimination signal.

As has been described above, according to the first embodiment, the macro-scoped correction process and macro-discrimination process are executed by the processor, whereby the circuitry scale for the macro-scoped correction process with a large reference region can be reduced.

Moreover, after the resolution and bit amount of the signals are decreased, the macro-scoped correction process and macro-discrimination process are executed. Thereby, the hardware scale and computation time can be reduced.

Furthermore, both the macro-discrimination and

the discrimination using characteristic amounts are employed, whereby the high-precision, high-resolution discrimination result can be obtained.

A second embodiment of the invention will be described.

In the first embodiment, much computation time is needed in the macro-discrimination process. Thus, there is the problem that the copying speed decreases. In the second embodiment, the processor does not perform macro-discrimination, and it performs only the macro-scoped correction process, thereby decreasing the processing time.

FIG. 13 shows the structure of an image processing section 10 according to the second embodiment. The structure of the second embodiment is substantially the same as that of the first embodiment. The difference is that a signal delay section is provided in an image region discrimination section 1105.

The content of the process in the second embodiment is described.

The second embodiment differs from the first embodiment with respect to the addition of the signal delay section, the process content of the image region discrimination section 1105, and the process content and process sequence of the synthesizing process section. An encoding section 102, a page memory 103, a decoding section 104, a color conversion section 106, a

filter section 107 and a tone processing section 108 are the same as those in the first embodiment. Thus, the description of these components is omitted here.

FIG. 14 shows the structure of the image region discrimination section 1105 in the second embodiment. The calculation of the characteristics amount is the same as that in the first embodiment.

The characteristic amount that is output by calculating the characteristics amount is subjected to reduction processing of the resolution and bit amount, and the result is stored in a memory 1410. Using a processor 1411, the image signal in the memory 1410 is processed. FIG. 15 illustrates the process flow. In this embodiment, only the macro-scoped correction process is performed, and the macro-discrimination process is not. The processing result is output from the memory 1410 to the synthesizing process section 1505.

In the first embodiment, the discrimination results are output after completion of the processing for the entire image. By contrast, in the second embodiment, each time a calculation result of the macro-scoped correction process is locally produced, the calculation result is successively input to the synthesizing processing section.

On the other hand, the signals output from the characteristic amount calculation sections 1401 to 1404

are delayed by the signal delay section 1413 and then input to the synthesizing processing section 1505. In the conversion processing sections 1406 to 1409, the processing is performed by referring to information of adjacent regions of a pixel of interest. As a result, a delay corresponding to the area of the reference region of the macro-scoped correction process occurs from the output of the characteristic amount of the pixel of interest to the completion of the macro-scoped correction process. To cope with this, the signal delay section 1413 delays the characteristic amounts from the characteristic amount calculation sections 1401 to 1404, whereby synchronism is established between the characteristic amounts, which are output from the characteristic amount calculation sections 1401 to 1404 to the synthesizing processing section 1505, and the discrimination signal after the macro-scoped correction process.

The points of the present invention according to the second embodiment are as follows.

The characteristic amount calculation results obtained by hardware are subjected to the macro-scoped correction by the processor.

The resolutions and signal bit amount of the characteristic amounts are decreased, and the resultant signals are stored in the memory.

Both the macro-scoped correction calculation

result and characteristic amounts are synthesized to produce a final discrimination signal.

As has been described above, according to the second embodiment, the macro-scoped correction process is executed by the processor, whereby the circuitry scale for the macro-scoped correction process with a large reference region can be reduced.

Moreover, after the resolution and bit amount of the signals are decreased, the macro-scoped correction process is executed. Thereby, the hardware scale and computation time can be reduced.

By using only the signals after the macro-scoped correction, a discrimination result with a relatively high precision and resolution is obtained, and the discrimination process can be executed almost in real time.

A third embodiment of the invention will now be described.

The structure of the image processing section of the third embodiment is the same as that shown in FIG. 1 in connection with the first embodiment. In the third embodiment, a plurality of process modes can be switched. In a first process mode, like the first embodiment, the macro-scoped correction process and macro-discrimination process are executed by the image region discrimination section. In a second process mode, like the second embodiment, only the macro-scoped

correction process is performed. The contents of the respective processes are the same as those in the first and second embodiments, so a detailed description thereof is omitted.

As has been described above, according to the third embodiment, high-precision discrimination can be performed in the first process mode, although a processing time is relatively long. In the second process mode, a processing time is shortened, although discrimination precision lowers.

As has been described above, the embodiments of the present invention can provide the following image processing apparatuses.

An image processing apparatus according to the present invention comprises one or more characteristic amount calculation sections for receiving image signals, calculating characteristic amounts of the image signals, and outputting characteristic amounts; page memory means for storing the characteristic amounts; calculation means, connected to the page memory over a bus, for subjecting the content of the page memory to an arithmetic process according to a predetermined program; and means for outputting a calculation result of the page memory.

An image processing apparatus according to the present invention comprises one or more characteristic amount calculation sections for receiving image

signals, calculating characteristic amounts of the image signals, and outputting characteristic amounts each having a lower sampling density than the input image signals; page memory means for storing the characteristic amounts; calculation means, connected to the page memory over a bus, for subjecting the content of the page memory to an arithmetic process according to a predetermined program; and means for outputting a calculation result of the page memory.

An image processing apparatus according to the present invention comprises one or more characteristic amount calculation sections for receiving image signals, calculating characteristic amounts of the image signals, and outputting characteristic amounts; page memory means for storing the characteristic amounts; calculation means, connected to the page memory over a bus, for subjecting the content of the page memory to an arithmetic process according to a predetermined program; and means for outputting a calculation result of the page memory, characterized in that the program calculates signal values by referring to signals of a pixel of interest and an adjacent region thereof, which are stored in the page memory, and a size of the adjacent region is switched according to an externally designated mode.

As regards the externally designated mode, there are at least two modes. In at least one mode, the

calculation processing speed for one pixel in the processor is equal to or higher than the input speed of the image signals.

An image processing apparatus according to the present invention comprises one or more characteristic amount calculation sections for receiving image signals, calculating characteristic amounts of the image signals, and outputting characteristic amounts; page memory means for storing the characteristic amounts; calculation means, connected to the page memory over a bus, for subjecting the content of the page memory to an arithmetic process according to a predetermined program; means for outputting a calculation result of the page memory; and discrimination processing means for receiving the output signal from the page memory and the characteristic amounts, comprehensively determining these signals, and executing a discrimination process.

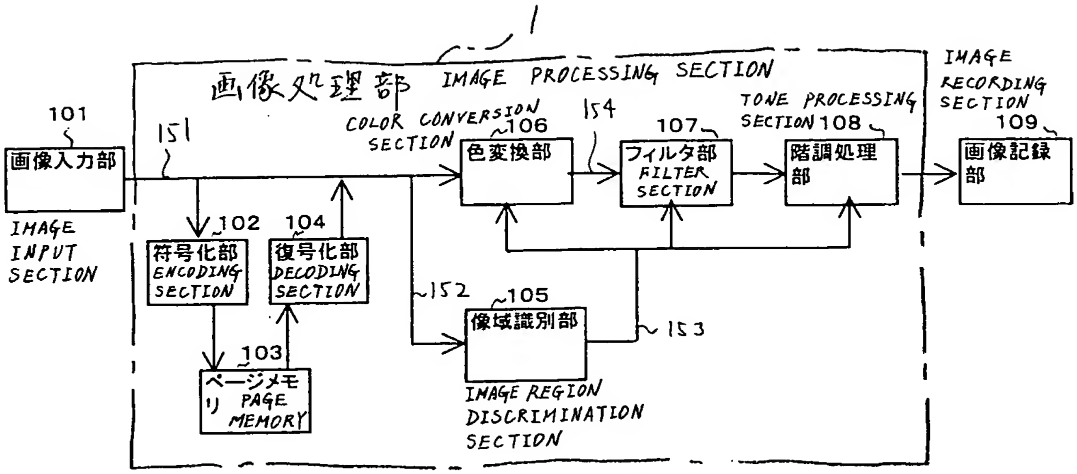
An image processing apparatus according to the present invention comprises memory means for storing image signals as such, or image signals that are encoded; means for reading out outputs of the memory means as such, or reading out outputs of the memory means which are decoded; one or more characteristic amount calculation sections for receiving read-out image signals, calculating characteristic amounts of the image signals, and outputting characteristic

amounts; page memory means for storing the characteristic amounts; calculation means, connected to the page memory over a bus, for subjecting the content of the page memory to an arithmetic process according to a predetermined program; means for outputting a calculation result of the page memory; and discrimination processing means for receiving the output signal from the page memory and the characteristic amounts, comprehensively determining these signals, and executing a discrimination process.

Additional advantages and modifications will readily occur to those skilled in the art. Therefore, the invention in its broader aspects is not limited to the specific details and representative embodiments shown and described herein. Accordingly, various modifications may be made without departing from the spirit or scope of the general inventive concept as defined by the appended claims and their equivalents.

ABSTRACT OF THE DISCLOSURE

In an image region discrimination section in an image processing section, a characteristic amount calculation result obtained by hardware is subjected to macro-scoped correction and macro-discrimination by a processor. Further, in the image region discrimination section, a resolution and a signal bit amount of a characteristic amount are decreased, the resultant characteristic amount is stored in a memory, and both a macro-discrimination result and the characteristic amount are synthesized to produce a final discrimination signal.



~~図1 第1の実施例の画像処理部の構成~~

FIG. 1

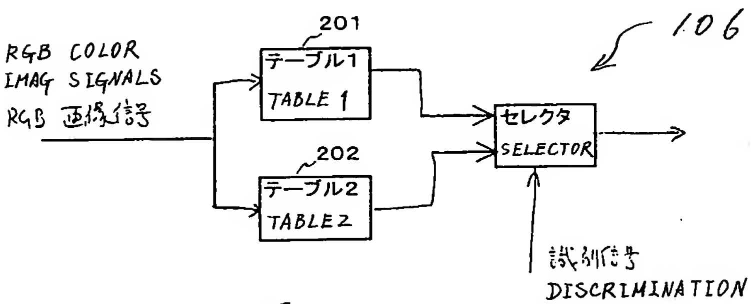
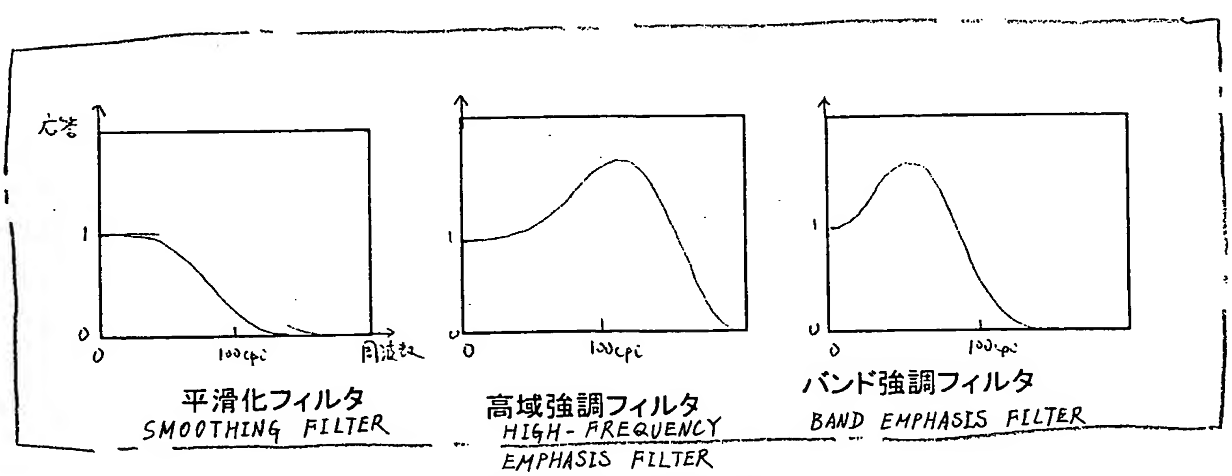


FIG. 2

図2 第1の実施例の色変換部の構成



~~図3 第1の実施例のフィルタの特性~~

FIG. 3

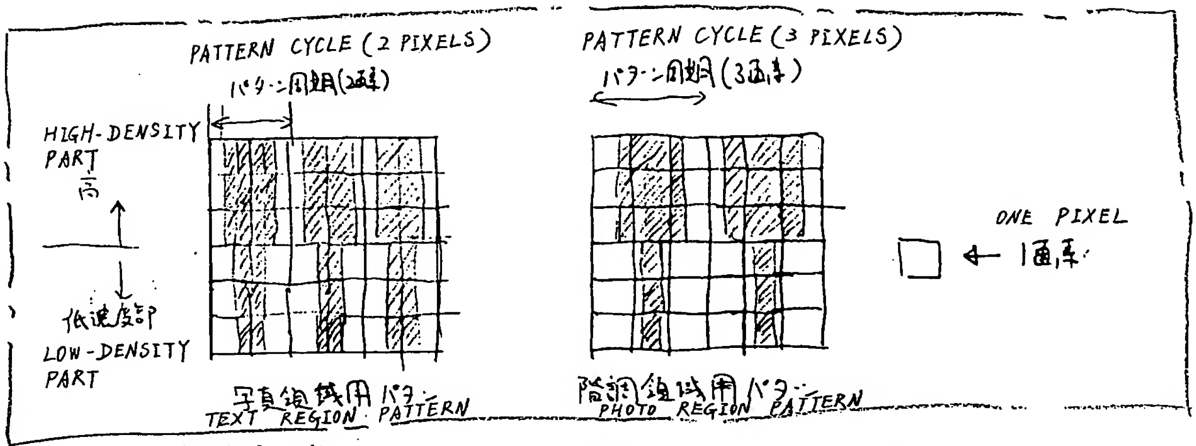


FIG. 4 ~~図4 階調処理部のスクリーンパターンの例~~

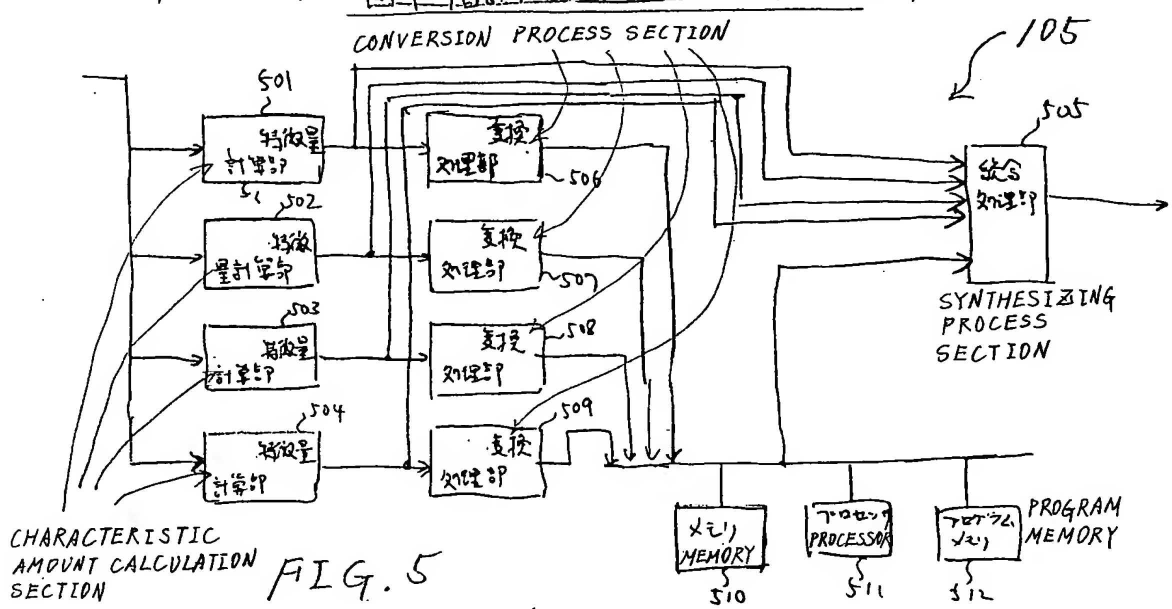


FIG. 5

~~図5 第1の実施例の像域識別部の構成~~

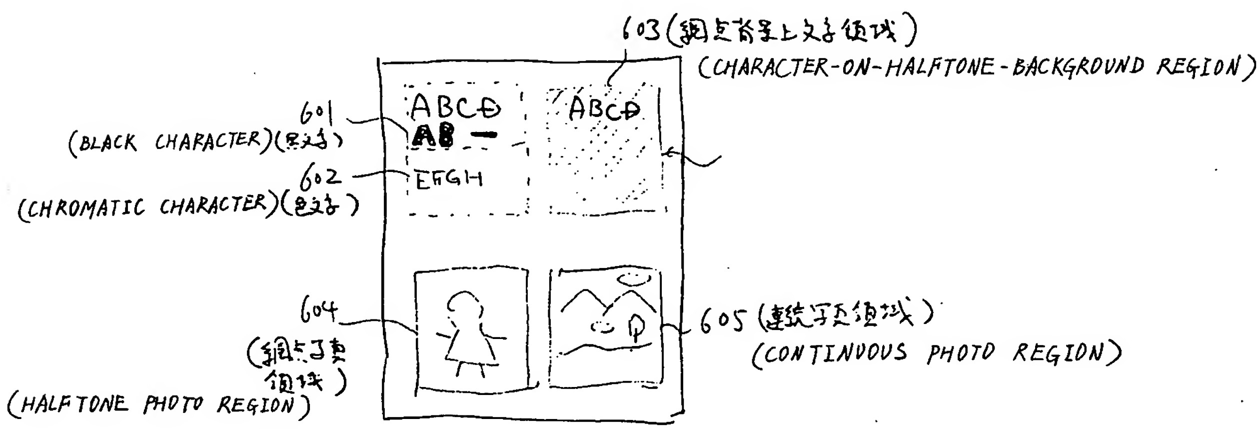


FIG. 6 ~~図6 原稿画像の例~~

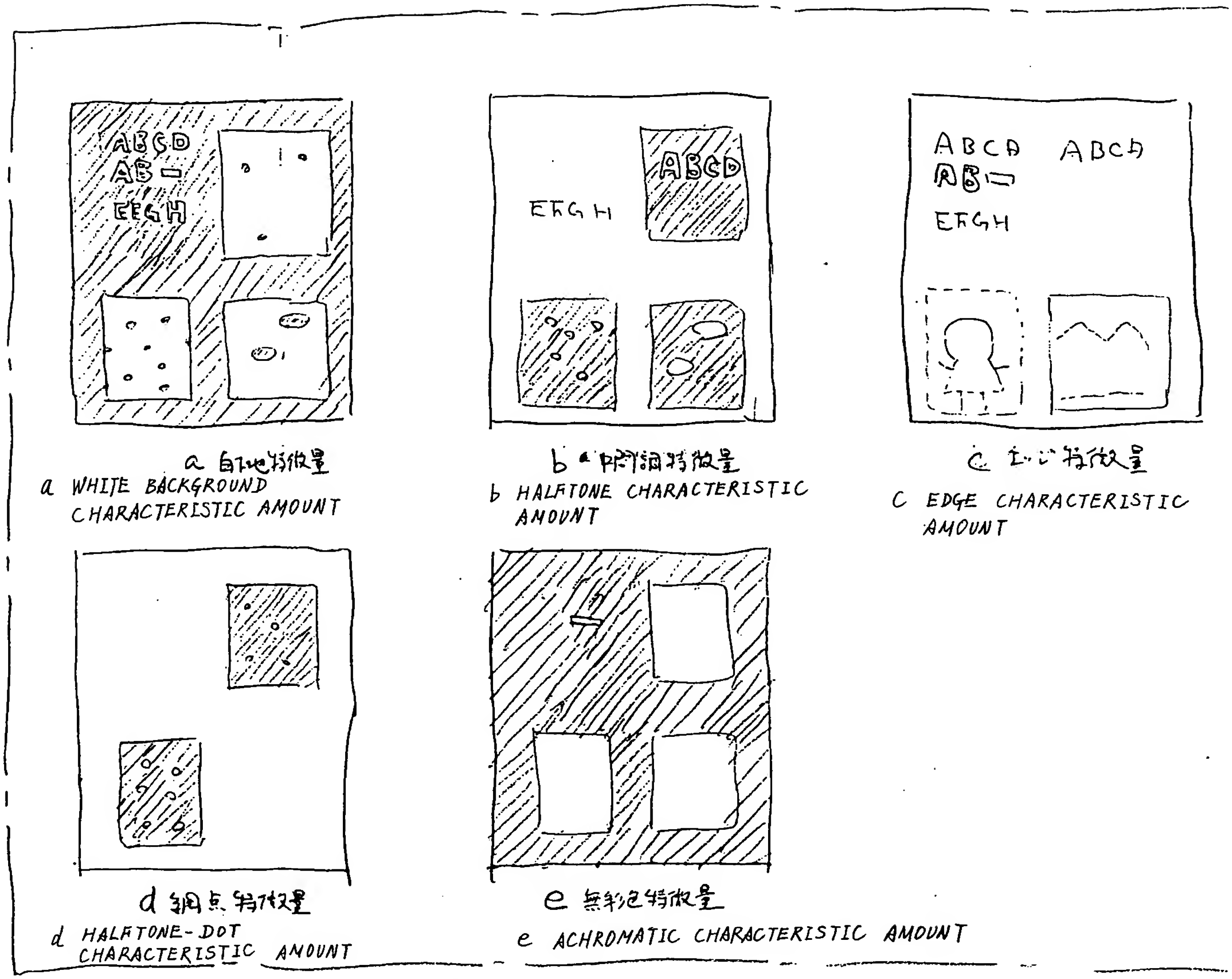


FIG. 7

~~図7 特徴量計算結果の例~~

ステップ1 — 白下地特徴量に対する大域処理 — MACRO-SCOPED PROCESS FOR WHITE BACKGROUND CHARACTERISTIC AMOUNT

↓

ステップ2 — エッジ特徴量に対する大域処理 — MACRO-SCOPED PROCESS FOR EDGE CHARACTERISTIC AMOUNT

↓

ステップ3 — 網点特徴量に対する大域処理 — MACRO-SCOPED PROCESS FOR HALFTONE-DOT CHARACTERISTIC AMOUNT

↓

ステップ4 — 無彩色特徴量に対する大域処理 — MACRO-SCOPED PROCESS FOR ACHROMATIC CHARACTERISTIC AMOUNT

↓

ステップ5 — マクロ識別処理 — MACRO-DISCRIMINATION PROCESS

FIG. 8

~~図8 プロセッサ処理のフロー~~

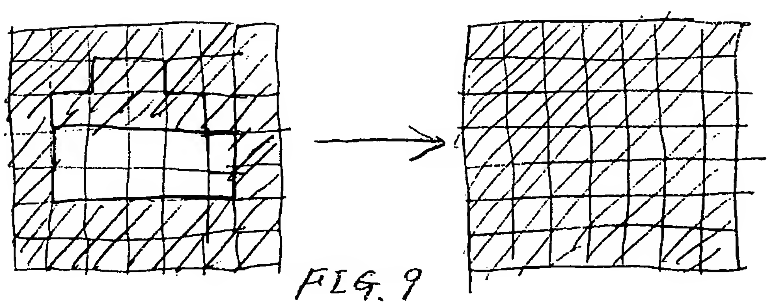


FIG. 9

~~図9 白下地領域に対するスメアリングの例~~

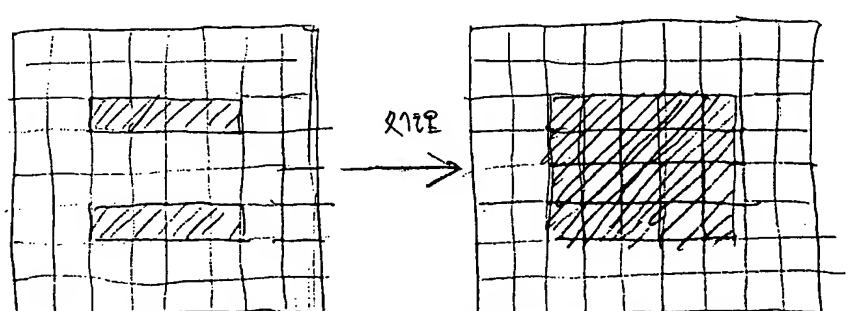


FIG. 10

~~図10 エッジ特徴量に対するスメアリング処理の例~~

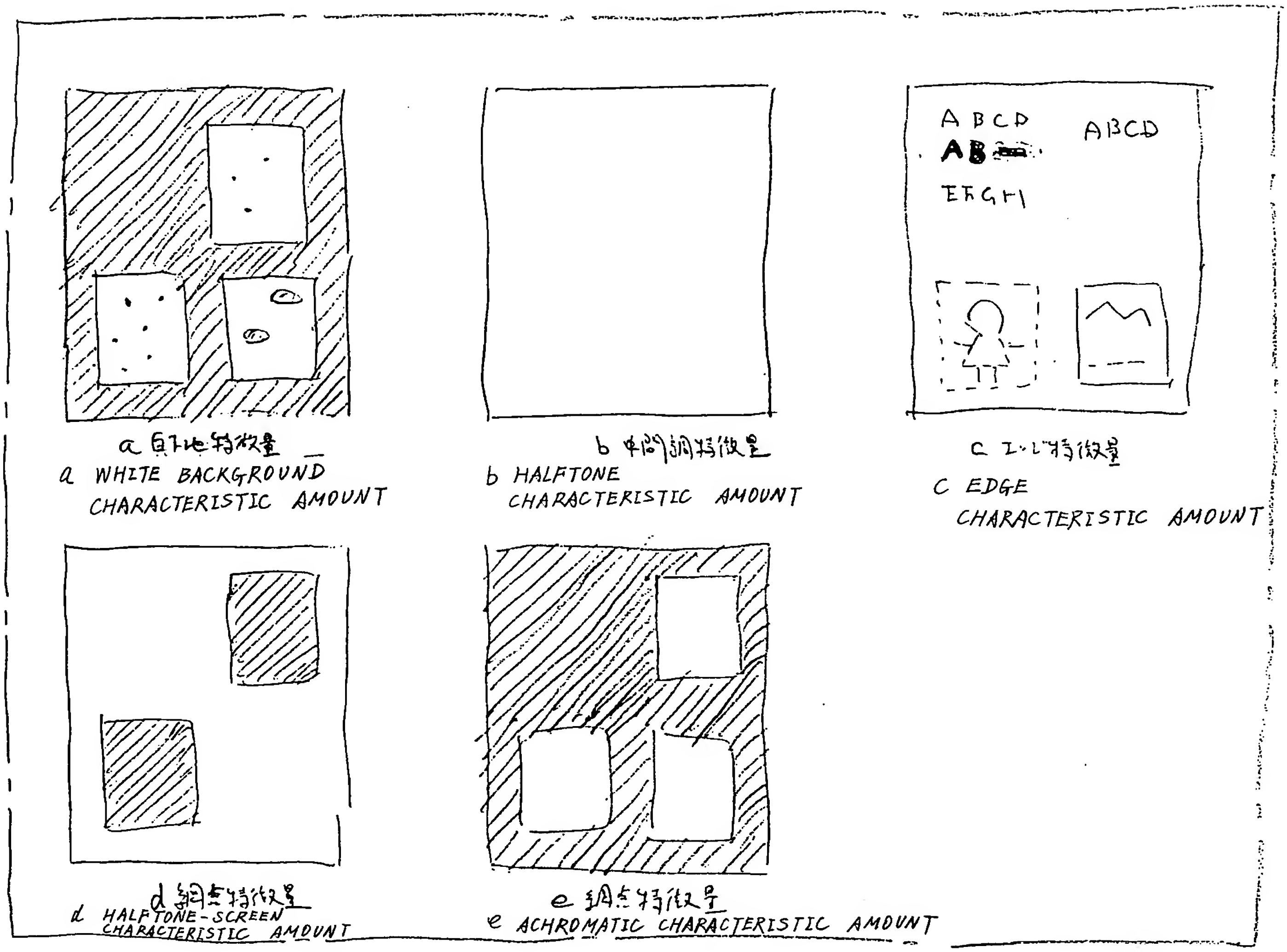

ABCD
ABCD
EFGHI
a WHITE BACKGROUND CHARACTERISTIC AMOUNT
b HALFTONE CHARACTERISTIC AMOUNT
c EDGE CHARACTERISTIC AMOUNT
d HALFTONE-SCREEN CHARACTERISTIC AMOUNT
e ACHROMATIC CHARACTERISTIC AMOUNT

FIG. 11

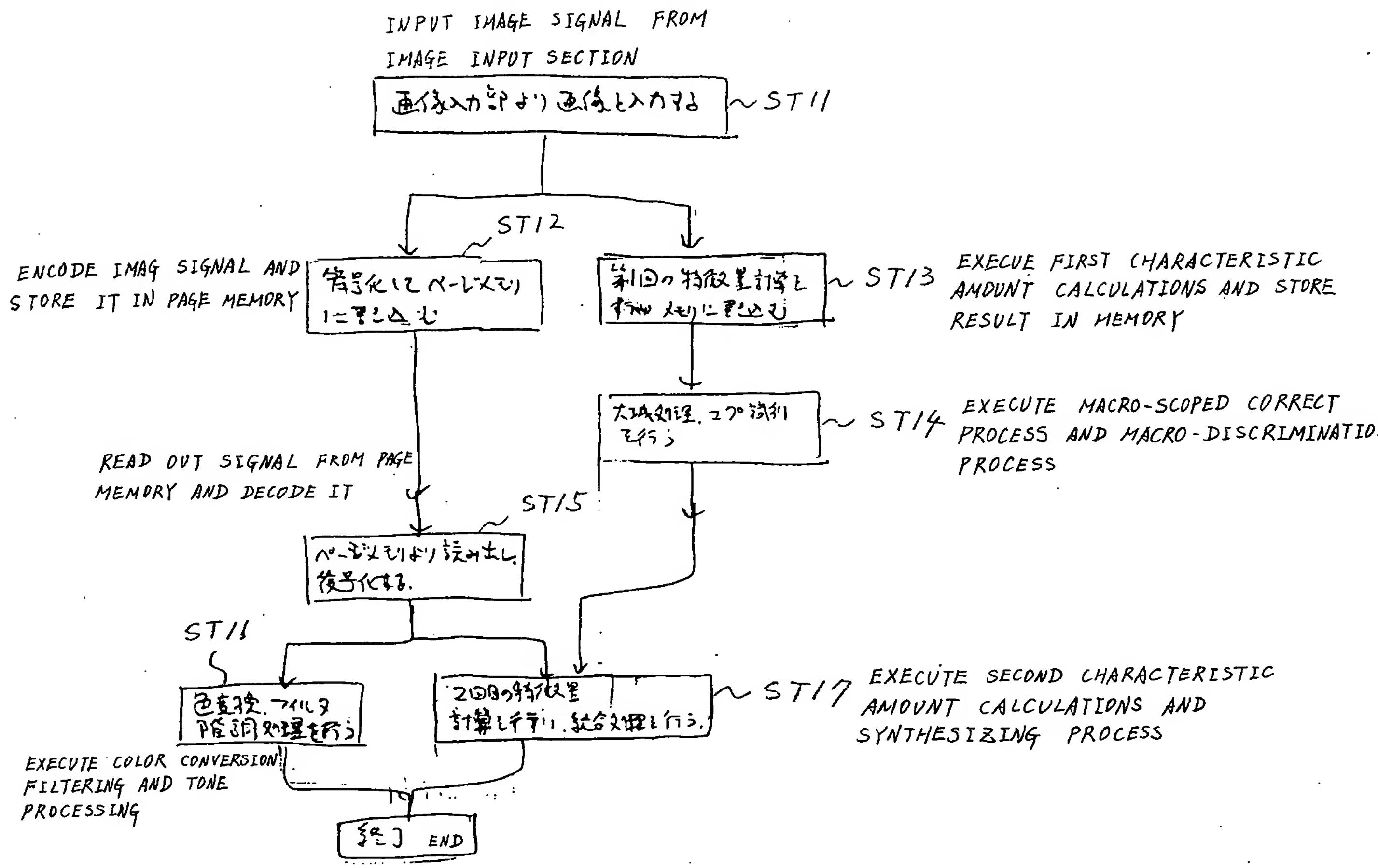


FIG. 12 ~~図12 第1の実施例の処理シーケンス~~

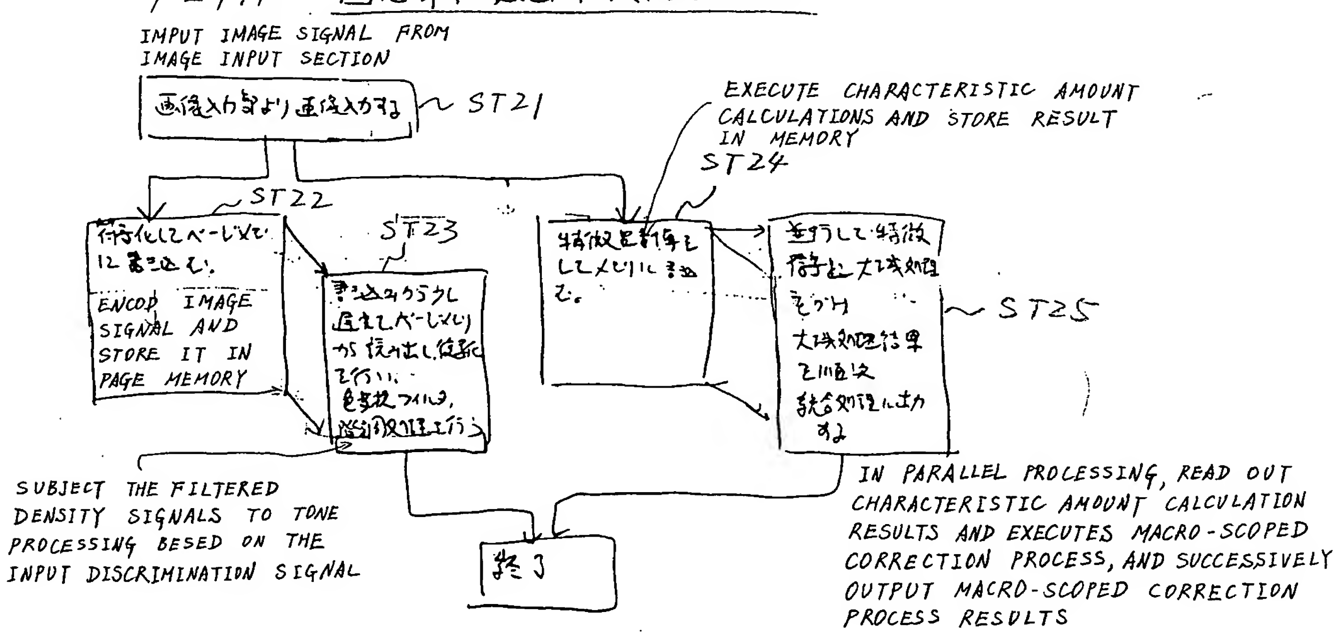
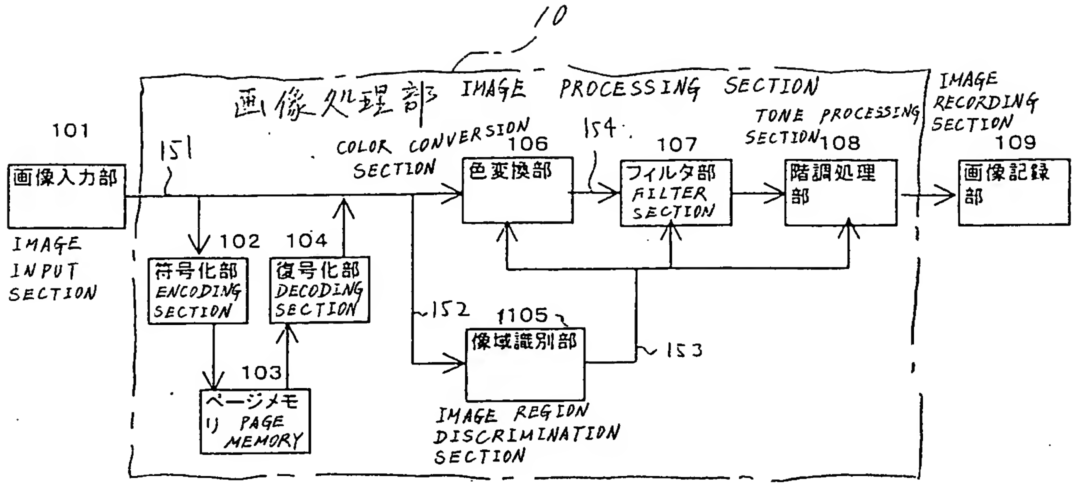


FIG. 15

~~図15 第2の実施例の処理シーケンス~~



~~図1 第1の実施例の画像処理部の構成~~

FIG. 13

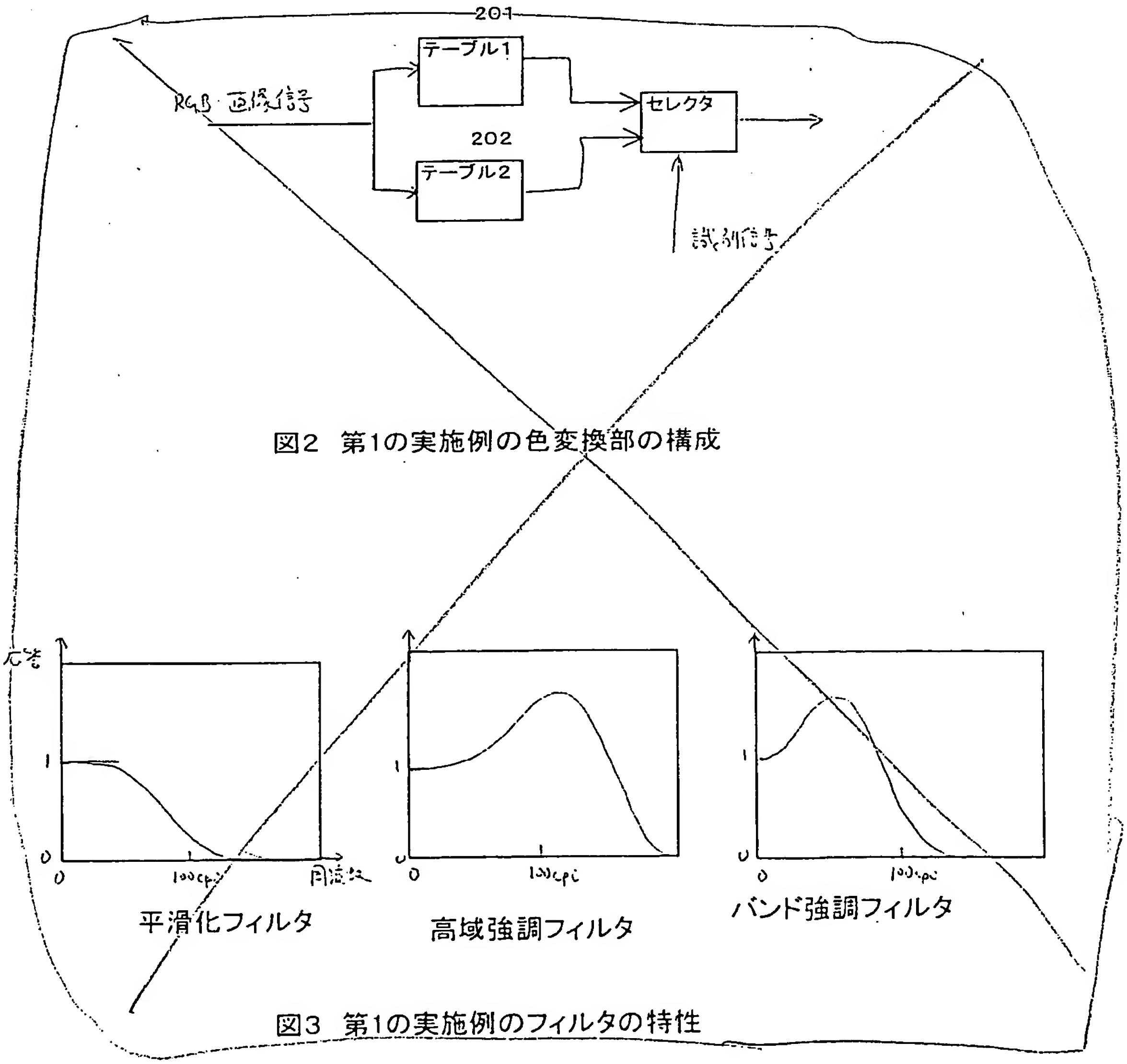


図2 第1の実施例の色変換部の構成

図3 第1の実施例のフィルタの特性

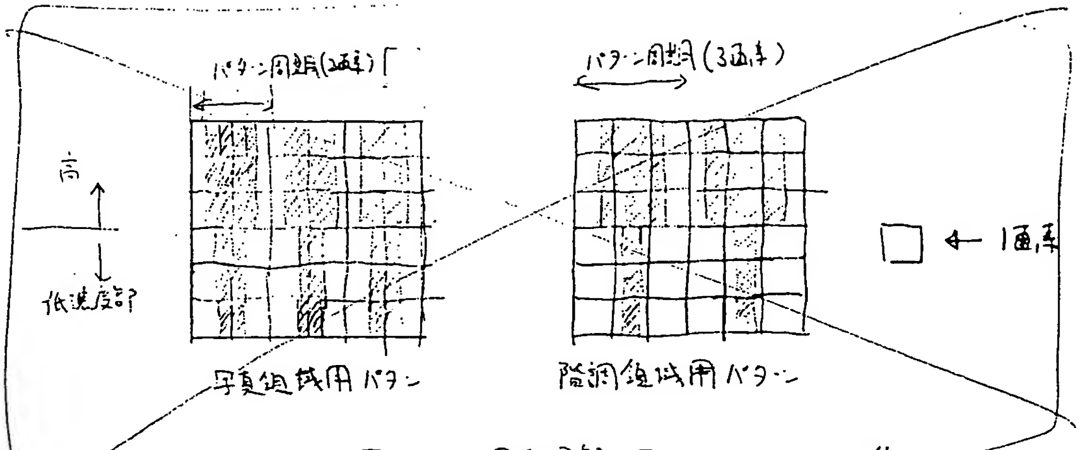


図4 階調処理部のスクリーンパターンの例

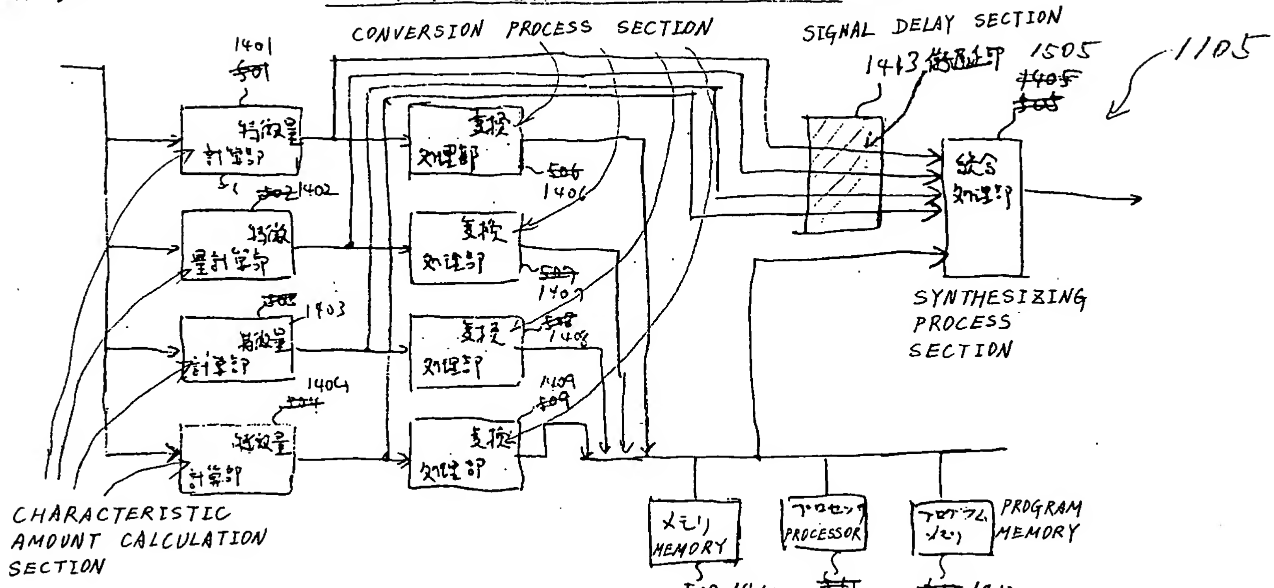


FIG. 14 ~~図8 第2実施例の像域識別部の構成~~

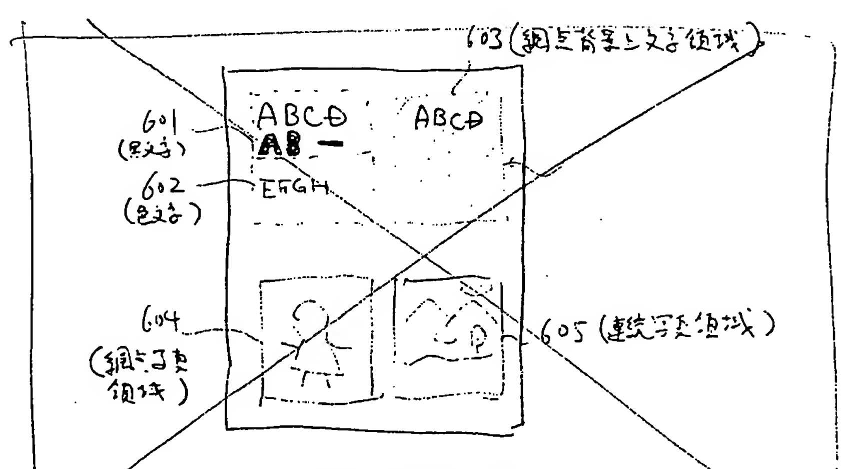


図6 原稿画像の例